LETTERS TO THE EDITOR.

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Engineering Equipment of the Manchester School of Technology.

The report on engineering work at the British Association Meeting at Southport in your issue of October 29 contains certain criticisms with regard to the engineering equipment of the Manchester School of Technology. The responsibility for the character of this equipment rests ultimately upon me as the professional adviser of the Technical Instruction Committee, and I would therefore seek some space in your valued columns for making reply.

The criticism takes two forms :—(1) that the laboratory equipment is unnecessarily complicated and beyond the capacity of the class of students the school is likely to obtain ; and (2) that in any case, even if justifiable as to its nature, it was wrong to put in so much plant at once, but that part of it should have been held back until the growth of students showed a necessity for it.

The reply to both is, that it was in the hope of attracting that very class of student the critic is so sure we are unlikely to secure that so extensive and elaborate a plant was installed.

The great defect of technical education as hitherto conducted in this country has been its restriction to the teaching of elementary engineering science and to a few stock laboratory operations, such as breaking specimens in a testing machine, taking indicator diagrams from steam and gas engines, and making the simpler hydraulic experiments. This restriction was necessary, because the pupil, being a youth fresh from school, who had never seen the inside of an engineering workshop, and had to be taught everything from the commencement, could not be expected to advance very far in engineering knowledge. When he afterwards went into practical work, the knowledge acquired at the technical school being of no immediate use to him, he was no better off than if he had gone straight from school to the works, and his employer was not slow to notice this and draw the inference that the work of the technical school was practically of no value to the engineering industry. This is why the large majority of employers take so little interest in "technical education."

In Manchester, on the other hand, we have broken fresh ground, and are attempting to convince the engineering leaders that if they provide us with only one or two of the best young men out of each of their works, who have spent a few years in the workshop, and who know the elementary parts of geometry, algebra, trigonometry, and mechanics, we can, with two years of study and experimental work, turn out a product superior in every useful respect to even the much vaunted Charlottenburg *diplomé,* and of real and immediate monetary value to the profession.

We propose to prove this by showing those leaders the practical utility and industrial value of the results of our research work, and also by returning to them their young men, not mere beginners without self-confidence (though stuffed with formulæ), but trustworthy observers, resourceful experimenters, and men of imagination, who are able to impart new ideas to those engaging them, and to help them to work these ideas out in a practical way.

Take, as an example, the experimental engine to which you refer as being a huge mistake.

Take it for granted that a large percentage of the waste in steam engines is due to the defective design of valves. If we can show to some of these young designers of the future by experimental research upon this engine how these valves are defective, and in what direction to look for improvement, we are surely aiming at a higher measure of utility than could be attained by demonstrations with any number of varieties of the market article, however modern.

In regard to the remarks made about the equipment becoming obsolete, the scope and object of the plant has again been entirely misunderstood. The laboratories are not intended to serve as museums of modern appliances which the student comes to examine, copy, and store his memory with, but as a collection of machines typical of the various branches of mechanical engineering, specially fitted up for the purpose of studying the action of those working fluids and those moving mechanical elements which are common to all forms of prime movers and energy absorbers, past, present, and to come.

With reference to the question of the size of the individual parts of the equipment, one of the things for which, in my opinion, local engineers must ever feel grateful to the Manchester Technical Instruction Committee is the courage they showed in putting down plant on a true engineering scale. No practical experimental results worthy of attention could otherwise have been obtained. It could hardly be expected, for example, that an engineer, wishing to know the laws of the action of automatic drop valves for a design of large high-speed pump, should rest content to be guided by experiments made with a donkey-pump, however elaborate they might be.

In concluding, may I give expression to my belief that the promise for the future of British engineering lies in practical experimental research, strenuously carried on either in the workshop- or the college-laboratory by men specially trained for the purpose, and that the sooner we get rid of the notion that teaching schoolboys some engineering theory and the making of a few stock laboratory experiments constitutes the proper education for the engineer of to-day, the sooner we shall begin to recover from the reproach of having fallen behind the foreigner.

JOHN T. NICOLSON.

On two Constants A_1 and A_2 in the Kinetic Theory of Gases.

MAXWELL has introduced two constants A_1 and A_2 in the kinetic theory of gases (*Scientific Papers,* vol. ii. p. 41), defined by the integrals

$$A_1 = 4\sqrt{2}\ \pi \int_0^{\frac{\pi}{4}} \frac{\sin^2\theta}{\sin^2 2\phi} d\phi,$$

$$A_2 = \sqrt{2}\ \pi \int_0^{\frac{\pi}{4}} \frac{\sin^2 2\theta}{\sin^2 2\phi} d\phi,$$

where

$$\theta = \frac{\pi}{2} - \sqrt{\cos 2\phi}\ K\ (\sin \phi),$$

K being the complete elliptic integral of the first kind with modulus $\sin \phi$. These constants enter into the discussion of various properties of gases, on the assumption that the gas molecules repel each other according to the inverse fifth power of the distance. The values of these integrals, as found by mechanical quadrature, are

$$A_1 = 2 \cdot 6595 \qquad\qquad A_2 = 1 \cdot 3682.$$

Constructing a graph of $\sin^2\theta/\sin^2 2\phi$, I chanced to notice that the convexity is turned towards the axis of ϕ, so that the quadrature used by Maxwell must make A_1 a little too large. With the second integral, the number of points near the maximum of $\sin^2 2\theta/\sin^2 2\phi$ is insufficient, so that the value of A_2 will turn out to be too small.

Of the different methods of evaluating these two integrals, that of Gauss (" Methodus nova integralium valores per approximationem inveniendi," Werke iii. pp. 163–196) evidently leads to more accurate results than taking a number of equidistant points. This method of quadrature can be applied in two ways. The integrands $\sin^2\theta/\sin^2 2\phi$ and $\sin^2 2\theta/\sin^2 2\phi$ can be expanded either in power series of ϕ or of $q = e^{-\pi\frac{K'}{K}}$, where K and K' are complete elliptic integrals of the first kind. Since

$$d\phi = 2/\sqrt{q}(1 - 4q + 6q^2 - 8q^3 + 13q^4 - 12q^5 + \ldots)dq,$$

we can effect the approximate integration by finding either the values of ϕ or of $\sqrt{q}$ between the limits of integration, proportional to the roots of zonal harmonics of nth order $P_n(\mu)$, and proceeding according to the method indicated by Gauss.

These tedious calculations were undertaken by Messrs.

K. Aichi and T. Tanukadate, post-graduate students in physics, with the following results :—

Considered as Power Series of φ :

For $n=6$: $A_1=2\cdot6512$ $A_2=1\cdot3704$ (Tanukadate)
For $n=7$: $A_1=2\cdot6512$ $A_2=1\cdot3704$ (Aichi)

Considered as Power Series of $\sqrt{q}$:

For $n=4$: $A_1=2\cdot6509$ $A_2=1\cdot3750$ (A. and T.)
For $n=7$: $A_1=2\cdot6511$ $A_2=1\cdot3704$ (A. and T.)

It thus appears that the number of points for $n=4$ is insufficient, but for $n=6$ or 7 the approximation becomes very close, so that the values of these two integrals are :—

$$A_1=2\cdot6512 \qquad\qquad A_2=1\cdot3704.$$

Maxwell's value of A_1 is about $1/300$ too large, and that of A_2 is about $1/600$ too small. Such small differences will not materially affect the theoretical results in which these two integrals enter, but it will be worth while to notice that the actual values are slightly different from those usually given in works on the kinetic theory of gases.

H. NAGAOKA.

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  October 8.

Leonid Meteor Shower, 1903

THE return of the Leonids was clearly observed here on the night of November 15. The night of November 14 was also clear, though at times a dark belt of cloud, which concealed the lower part of Orion, extended itself along the eastern horizon to the foot of Leo, and occasionally also small patches of cloud dimmed or caused a momentary disappearance of stars in or around Gemini. These slight impediments to observation continued also on the next night until between two and three o'clock on the following morning. It had been intended to commence observations here as early as the night of November 11, as the writer had anticipated that the Leonids would put in an early appearance in the present year; cloudy skies, however, prevented the possibility of knowing if these anticipations were realised. During a watch from 10h. 20m. to 12h. 30m. on November 14 (local time) eleven meteors were observed, almost half of which were Leonids as bright as stars of the first or second magnitude. The radiation from Leo was regarded as surprisingly good, considering the hazy or clouded appearance of the horizon, which rendered that constellation invisible until after midnight. In a forecast made by the writer for the present year he found that, so far as the Leonid epoch of November 14–16 was concerned, the maximum would fall between the hours 13 and 14 on November 15; but it was considered that the display on the latter night would be weak, owing partly to the reported insignificance of the Leonid shower on the night of November 15, 1902, the preparations for the due observation of which were generally frustrated by unfavourable atmospheric conditions. When, therefore, the radiation from Leo was found to be so pronounced during the early hours of the night of November 14, the writer found that he had entirely underestimated the probable strength of the shower for 1903. The watch, however, was not prolonged beyond 12h. 30m. on the night of November 14, as there was no possibility of a star shower taking place on this night, though, no doubt, there were manifest signs that the Leonids might be unusually numerous. The first watch on the following night lasted from 9h. 15m. to 10h., during which time four meteors were seen, one of them being a Leonid as bright as a first magnitude star. Its appearance was revealed by the rich streak it left in its wake as it slowly rose from the invisible radiant. The watch was resumed at eleven o'clock, and whatever misgivings might have been felt for abandoning the lookout on the previous night were quickly dissipated by the appearance of as many Leonids in the first quarter of an hour's observations as had been seen during a period about five times as long on the preceding evening. Between 11h. and 11h. 30m. the meteoric rate was twenty-two per hour for one observer facing due east, but by midnight it had fallen to sixteen per hour,

though sporadic meteors were included in the count. Between 12h. and 13h. drifting patches of cloud probably prevented several meteors from being observed, and the rate did not rise above thirty per hour, but at 15h., when the sky had become quite clear, Leonids were appearing at the rate of one per minute. During the next half hour forty-one shooting stars were counted, and this high rate was more than maintained for the next two hours; indeed, it was estimated at one time that the meteoric rate was easily 200 per hour for one observer. The brilliancy of the display was as remarkable as its numerical strength. When the shower was at its maximum, few of the shooting stars seen were less bright than the second or third stellar magnitude; indeed, most of them, if observed apart, would have merited individual description, and almost every third or fourth meteor might be called a bolide. To an observer looking eastwards the radiation from Leo was very marked, but a few instances were characterised by a centripetal rather than the usual centrifugal motion as regards the well-known radiant. The most noted of these exceptional cases occurred between one and two o'clock, when a bolide of surpassing splendour passed slowly downwards, leaving a rich trail across the stars ε and ζ Leonis. When close to the " Sickle " it exploded with a vividly white flash that imparted to it an almost startling brilliancy, and an instant afterwards a meteor as bright as Sirius made its appearance about twenty degrees further on, shooting down towards the horizon in a path that seemed to be a production of that of its more brilliant predecessor. Another meteor brighter than Jupiter shortly afterwards moved slowly downwards from within the " Sickle," passing between γ and η Leonis one-third nearer the latter than the former star, and pursuing a course parallel to the line joining η and Regulus. This west-to-east motion of the most brilliant members of a meteor display (for it has been noticed on other occasions by the writer) appears very significant. Several shooting stars shot from ε Leonis to β Canis Minoris, or slightly below the latter star. There seemed to be a second centre of emanation much lower down in the " Sickle " than that indicated by the foregoing meteors, and there was certainly another radiant altogether far away from Leo, and situated probably in or near Perseus. Several bolides passed out of sight overhead, arresting the attention only by their exploding flashes that momentarily illuminated the whole heavens. The pear-shaped appearance of meteors in the morning hours was very remarkable. These left rich trains which, like the meteors themselves, appeared of a yellowish tinge in the light of the waning moon or in the increasing twilight. Other members of the star shower dissolved in bright streaks, or made their appearance as vivid flashes of light, in the latter case generally at a great distance from Leo, bursting forth at one moment near the Great Bear, and in the next in the neighbourhood of Sirius. The largest number of meteors visible at one time was four. At six o'clock the activity of the shower, though considerably diminished, was still, even in the morning twilight, very noticeable.

The somewhat prolonged duration of the meteor shower affords some measure of its intensity, and it is probable that it has been widely observed, notwithstanding the fact that the notion of the supposed connection of the Leonids with the comet of 1866 precluded the possibility of such a striking meteoric occurrence in 1903, for the present is unquestionably the brightest Leonid display that has been subjected to European, and very probably also American, observation since the brilliant star showers of 1866–8. It is noteworthy that the present shower resembles very much in intensity and also in other particulars a bright display in 1865, in which year it was estimated that one thousand Leonids might have been counted by observers in England on November 13. A lapse of thirty-eight years separates the two events, and this interval suggests the nineteen year-period which has already been noticed (NATURE, April 23) in the case of all the April meteor-displays of the past century, and has also been shown (*English Mechanic,* April 3) to connect several important Leonid star-showers extending over the same time. If this be so, it is possible that the years 1904 and 1905 may be marked by even richer meteoric occurrences than that which has taken place on the present occasion. JOHN R. HENRY.

Dublin, November 18.